NOTES FOR THE AMATEUR BOTANIST IN THE PHILIPPINES—*Coulter*

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THE AMATEUR BOTANIST

IN THE

PHILIPPINES

BY

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ISSUED ESPECIALLY FOR THE USE

OF TEACHERS

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PREFACE

To many persons variously situated in the Philippine Islands any means, however limited, which seeks to give an insight to some of the general facts of plant life with special reference to Philippine conditions, may be welcome. No effort is made herein to furnish a guide to the study of Philippine botany with any pretence of completeness, which neither the available data nor the public demand would warrant. The present purpose will be thoroughly served if adequate guidance or suggestion is found herein for a little botanical work where opportunity and inclination already exist.

It is with a desire to furnish such means, by suggestion rather than by explicit direction, that this publication has been put out.

Whether such work be undertaken merely as pastime or with some material end in view there is no question of its benefit. The British in many of their tropical colonies, conspicuously in India, have been greatly aided in the accumulation of botanical data, both for economic and for purely scientific ends, by intelligent amateur work. The same is true of the Dutch in Java and of the French and Germans in lesser degree. That it will be so in the Philippine Islands

no one will question who appreciates the instinctive desire of an American to "know about" the things around him.

No region of the world presents a more nearly virgin field for botanical work than the Philippine Archipelago at the present time. In no one of the botanically unexploited regions of the world is the opportunity for the rapid accumulation of important data apparently as good as it is here. To those chiefly interested in the economic value of the plants of the islands, as well as to the professional and amateur botanists, the situation must appeal with equal strength.

Despite the fact that many important observations upon plants may be made in ignorance of the scientific names of the forms in question, the value of such observations is, of course, greatly increased by identification with published descriptions, and the primary concern of the botanist in the field must be the scientific determination of the forms he meets. All correlation of individual work with the work of other botanists depends upon such determination. Unfortunately no botanical work exists which might be used in the Philippine Islands in the way the manuals of Gray or Britton and Brown may be used in the Eastern United States for the easy determination of forms met in the

field. But perhaps the very absence of such an aid makes the work more interesting. Its existence would mean that the field had been already well worked and would at once practically eliminate the stimulating possibility of altogether new discoveries. However, the means of the preservation of the critical organs of a plant (leaves, flowers, and fruit) are easily obtainable and such preservation will make identification possible at any botanical headquarters, if the form in question has been previously described, and lead to its ultimate publication as a new species if it happens to be such. It is such collecting, done with the intelligence which can be easily acquired by study of general botanical facts, which is the most important aid the amateur can render to the end of a full knowledge of the distribution of the plants of the islands.

Yet it is not to be said that the amateur needs to be limited to the making of collections. Plants are divided into families and genera before they are finally divided upon the basis of the finer distinctions which constitute a species. That a key to the genera of the plants already reported upon the Philippine Islands can be made serviceable for the amateur from data already in hand there is good reason to believe. The determination of the genus of a plant in these bo-

tanically unknown regions should give at least an equal thrill of satisfaction with the running down of the final specific distinctions of a plant from a New England farm.

Nor need the work of the amateur in the Philippines stop even with generic determinations. After all, even the most critical determination of new species is but a means to the end and is very far from being the end itself of botany. Plants are living things as much as animals and the end of botany lies within this fact. An herbarium is a collection of dead things, and the corpses of the plants within it are ticketed and labelled as the mortal remains in some great catacombs might be. It is but the beginning of work upon plants as living things. Classification or taxonomy is certainly essential to all other botany, and a knowledge of it prerequisite to intelligent botanical work of any character, yet it is in the study of the lives of plants that the livelier interest of the amateur botanist should be, if it be an interest at all deep. In this larger and more philosophical field lie the great problems of modern botany. There is no reason why the amateur should have no concern with them. There is even richer return of facts hitherto unknown to be expected in this field in the study of Philippine botany than in the more immediate promise of the discovery of new species.

Manila Normal School, September, 1902.

CHAPTER I.

AMATEUR NATURE STUDY.

Even a superficial knowledge of botany is a valuable asset in the enjoyment of one's natural surroundings. Geology and botany are sister sciences in their fundamental relation to an understanding of the conspicuous features of the earth's surface. To learn their principal facts is to learn the rudiments of the language in which the book of nature is written. To pursue such study with patience is to awaken keen interest and a surprised enjoyment in a field of fundamental knowledge utterly neglected by the great majority of persons.

To no one more than to the traveller in strange lands is such acquaintance a benefit. It gives him power to comprehend strange and conspicuous facts which otherwise he must needs accept with wonder as simple and unquestioning as an Igorrote might have on first seeing an automobile.

To no one more than to him whose duties keep him at some isolated post, far away from the ordinary enjoyments of society, may such knowledge furnish a needful and an unfailing source of entertainment. A residence which might otherwise be boresome to the last degree, enerva-

ting to moral, mental and physical fibre, may be by such means enlivened, and the whole man stimulated in the practice of a study, pleasurable to the point of excitement, whose text is all out-doors.

The average American has not gone far in the development of such interests. What may be called the American spirit is, first of all, a material spirit, an interest in ends immediately effective, a spirit which turns to instant needs. With such spirit, and in the time when material advancement has gone forward by leaps and bounds, the cultivation of a well informed interest in nature for its own sake prospers but poorly. The eager questions of youth about facts first observed, the boy's ardent quest for the new and strange in field and woods, these, promptings though they be of the first and freshest instincts of keen awakening minds, are soon forgot in an environment where the best rewards are for the most successful, and success means little more than the acquirement of financial resources. Hasty deprecation of such spirit, despite its choking out of instincts toward naturalness and simplicity and its fosterance of what is artificial, is not intended, nor, in the opinion of the writer, warranted. This spirit with all its perversion of normal personality, despite the artificialities it engenders, is in itself natural, and, in results,

has been most efficient. We have it to thank, as a people, for the condition into which we are now emerging in which, material success being achieved, opportunity for broader enjoyment and development is everywhere enlarging.

Even in the Philippine Islands this condition is widely exemplified. The success of the nation has given us the overcharge of a new and wonderful country. The service of the government demands that many hundreds of capable Americans be scattered through it in more or less permanent residence. An adequate and certain income is assured to these persons, joined with ample opportunity for the following of a natural bent, at least in so far as that bent leads to nature. Opportunities for observation which, a few years ago, so far as America is concerned, were limited to the exceptional traveller, are on every hand. It is eminently unreasonable that they should be neglected.

The point deserves to be emphasized that an enjoyment is to be had in nature study far beyond the usual expectation of him who is diligent enough to undergo the small drudgeries of the beginner. Its value in quickening powers of observation and close reasoning is unquestionable. The satisfaction which it brings to the inquiring mind (and all normal minds are inquiring) is obvious. It stimulates the inherent love to be

abroad among the live things of the world and to learn their secrets, it makes keener the half-forgotten affection for the fields and forests in giving it something definite and tangible to feed upon, it quickens the high instinct of kinship with all animate creation.

Finally we dare urge in its behalf an utilitarian as well as a moral value. Too often it has been remarked that, once the game of fortune-getting is won, the American is apt to be without further resource of sustained and healthy enjoyment. Time hangs heavy on his hands. Why earn independent leisure if the possibilities of enjoyment of that high luxury be lost? The cultivation of interest in study of the facts of nature is certain to meet that question by amending it. Possibilities of enjoyment are opened on every hand. The man of independent means with an active interest in scientific work has been a most important factor in the progress of knowledge, but he has been far oftener an Englishman than an American. But the "leisure-class" is fast approaching as formidable proportions in America as in England. Its value as a part of the social fabric may only be admitted in so far as its splendid potency finds ways of individual betterment and service to the social whole. The study of the facts of nature, though perhaps not primarily altruistic, is certainly one of these ways.

CHAPTER II.

COLLECTING AND NOTE TAKING.

Aside from the months of almost daily heavy rains, the preservation of plants for herbaria can be easily accomplished in any part of the archipelago. What difficulties there are lie in the original collecting in the field, and even here it is a comparatively simple matter aside from securing the critical organs (flowers and fruits) of the higher trees. Thorough drying under pressure is the principle to be observed in the preservation of plants for herbarium purposes. Any fairly tough paper of light-weight and capable of readily absorbing moisture will serve for "dryers." A very serviceable paper is obtainable from the Chinese merchants, who use it for wrapping. The only objection to this paper is that its thinness necessitates the use of three or four folds between each specimen. Bamboo frames about 19 x 13 ins. are convenient for carrying the dryers in the field. The dryers should be placed between these frames and the edges of the frames tied. It is preferable to put specimens between the sheets of this primitive portfolio directly upon collection rather than to bring them home in a tin box. The former method

facilitates order, both in the specimens themselves and in the field notes which relate to them, and, by tying the edges of the frames as tightly as possible, the pressing process is begun at once. Save for woody plants, the initial pressure should be comparatively light; the equivalent of about 25 or 30 pounds' weight. Within 12 hours the pressure should be increased to 50 or 60 pounds. A pair of boards without warp, about the size of the dryers, and a heavy stone form a simple and efficient plant press. The frequency with which the dryers are changed should depend largely upon the judgment of the collector. The specimens must be dried as completely as possible and with the greatest rapidity practicable to prevent the beginning of mould and decay before the process is complete. Of course fleshy plants will take much longer to dry out than thin ones. In general, the dryers should be changed four or five times within the first 48 hours, and at least once a day for three or four days after that. Greater average humidity of the atmosphere makes the drying process generally more difficult in the Philippines than in the United States. The moist dryers must always be thoroughly sun-dried before being used again. It is this necessity that makes collecting almost an impossibility during the rainy season.

A convenient size for the dryers is 18 x 12 inches. (The dimensions of the bamboo frames are given with reference to this size.) The Chinese wrapping paper does not, however, fold easily into this size, but into one some inches larger. The standard herbarium sheet is 16⅔ by 11½ inches and specimens should be made of such size that they may be pasted upon such a sheet. It is desirable to place loose newspaper sheets between the dryers and to place the plants when collected upon these. The plants may be carried on these sheets through all the changes of dryers. Besides being a time saver, this plan lessens the chance of injury to delicate plants.

"A botanical specimen, to be perfect, should have, root, stem leaves, flowers (both open and in bud) and fruit (both young and mature). It is not, however, always possible to gather such complete specimens, but the collector should aim at completeness. Fragments, such as leaves without flowers, or flowers without leaves, are of little or no use. If the plant is small (not exceeding 15 inches) or can be reduced to that length by folding, the specimen should consist of the whole plant, including the principal part of the root. If it be too large to preserve the whole, a good flowering branch should be selected, with the foliage as low down as can be

gathered with it, and one or two of the lower stem-leaves, if any, should be added, so as to preserve as much as possible of the peculiar aspect of the plant. The specimens should be taken from healthy uninjured plants of a medium size." (Flora Hongkongensis, Bentham.)

It would be the exceptional plant which would permit the gathering of a perfect specimen upon a given date. Usually the flowers and fruit are separated by a considerable interval of time, although there are many plants whose fruit appears as a result of the earlier flowers while later flowers are still appearing.

However, the difficulty of obtaining perfect specimens should be no damper upon a collector's enthusiasm. It simply narrows a field which, without such limitation, he could never hope to cover. It means that he will be wise to pass by the majority of forms he meets, for the majority of forms at almost any given time will be without the organs which are essential to certain determination. (The maturity of the fruit is usually not essential.) Attention should be focussed then upon forms which are in flower. Here at once arises the necessity that the collector shall know a flower when he sees it, which is not so simple a matter as may be supposed. This is not the place to enter into a discussion of floral morphology, but

it needs to be emphasized that the flowers of many plants, especially of trees, are inconspicuous enough to easily escape the casual observer. Calyx and corolla, the organs which "advertise" the presence of the flower, are often completely lacking, but where the essential organs, stamens and pistil, are present, the flower is no less a flower for being "naked." The desirability, for any one attempting to do systematic collecting, of a familiarity with the variations in flower and fruit forms, such as may be obtained from almost any elementary text-book, is obvious.

The taking of field notes should always go hand in hand with collecting, and it is here that there is far more desirability of judgment and capability of correct observation than in the mere act of collecting; it is here that a background of appreciation of the fundamental principles of plant life, of the difficulties which the plant has to overcome, of the effect of external factors upon it, and of the principles of organic evolution, are of especial value. This, too, a good elementary text should supply. But a lack of detailed information upon these subjects should in no way deter. It is judgment and accuracy of observation which are the prime essentials; with these, one is apt, in the field, to form far better, clearer ideas of plant life than the best text in the world might give.

Field notes should include, primarily, a record of the date, the locality, and the character of the situation in which the plant is gathered. If the specimen in question be only a portion and not the complete plant, an accurate general description of the plant is essential. This would include notes on general appearance, stature, habit of branching, diameter of main stem or stems, and, if a large shrub or tree, a description of the bark. Such notes as these, however, are little more than the act of collecting itself; the notes which call for original thought cannot be directed in detail. They will be notes upon special adaptations of plants to their environment, upon the limits of the conditions under which a given form seems to thrive, upon reproductive capacity, upon the effect of different conditions of soil character and water supply upon the vegetation, and the like, indefinitely. And here it should be emphasized again that the observation and valuable record of such matters does not demand large botanical knowledge as a fundamental prerequisite. Such knowledge is a great aid to interpretation, but the observation of the original facts, which are the fundamental things, depends upon the acuteness of one's native senses. Important contributions of facts may of course be made by one who is quite unable to interpret them.

Observations upon the reproductive capacity and rate of growth of the valuable timber trees are of special value in the present lack of knowledge upon these points. In another chapter there is a discussion of the fact that the "annual ring" character, which affords convenient means for judging the rate of growth in trees in temperate regions, is practically lacking in tropical trees. Yet it is obvious that such knowledge is essential if the valuable timbers are to be cut in such a manner as to give a constant supply. Important observations can be made in this connection by the amateur. They are of primary importance to the Forestry Bureau.

A distinct and particularly important feature of the note taking should be the making of a careful record of the native names. The native terminology for all objects in nature is developed to a surprisingly high degree and very important service will be rendered in carefully associating these names with specimens from which scientific determinations may be made. There is great variation in these names among the different tribes. Vidal, chief of the former Spanish bureau of forestry, reports as many as 12 different native names for the same tree. The unraveling of this synonomy may be greatly aided by the notes of collectors in different parts

of the islands. It is almost indispensable to have a native for a companion upon botanical excursions. Members of the native tribes such as the Igorrotes, the Negritos, the Aetas and others will generally be found to be of far greater assistance than the more civilized Filipinos. In collecting from trees their assistance as climbers is essential.

Probably enough has been said to make it plain that any collecting which is to have real botanical value cannot be a hasty and miscellaneous gathering together without consideration of anything which looks interesting. Such work causes more trouble than it is usually worth. A good plan for the beginner might be to spend at first at least half an hour in the collecting and noting-up of each specimen. The notes should be made before the specimen is in the portfolio, and a system of numerical correspondence between notes and the specimens to which they refer should be very carefully employed. Nothing is more exasperating than not to be able to place absolute dependence upon the correspondence of numbers in the notes with the numbers of the specimens.

CHAPTER III.

GENERAL CONDITIONS.

It is natural for the American in the Philippines to compare the conditions of the vegetation here with the regions with which he is familiar in the United States. The surprise in such comparisons has doubtless lain more in the general similarities than in the striking differences of aspect, at least as to luxuriance. It is a popular impression in temperate regions that a wonderful luxuriance and rankness of growth is to be found everywhere in the rainy tropics. Although not infrequent, such vegetative conditions are the exception rather than the rule in the Philippines. The great variety of forms, however, is everywhere impressive. This is conspicuously true in the forests where probably at least eight varieties of trees may be found for one in the United States. The absence of "pure stands" of single kinds of trees is also striking. *

Two great factors give especial interest and importance to the flora of such a region as the

* Between two and three hundred distinct species of timber trees have been recorded by the Forestry Bureau for every considerable area which has been surveyed.

Philippine archipelago. The combination of insular conditions and situation within the rainy tropics, added to the fact that this archipelago is practically an unworked field, affords a condition which for complexity as well as tremendous abundance of botanical problems is almost unsurpassed. Here at hand lie data whose organization would go far in the solution of many of the most vexatious botanical questions.

The greatest luxuriance of plant life in the world lies within the rainy tropics. It must not be assumed, however, that such luxuriance is to be found indiscriminately in all parts of the islands. Such is very far from being the case.

The best known forests of the islands, those from which the bulk of timber is being cut, are not of the rain-forest type with its hot-house conditions the year round, but rather of the monsoon type which is hardly more luxuriant than a forest of mixed hardwoods in the United States. These forests lie on the uplands where drainage is rapid. The rainfall in these regions is divided with such decided inequality between the "wet" and the "dry" seasons that, during the latter, there is a more or less conspicuous reduction of foliage. The dry season corresponds to the winter of temperate regions in so dividing the year into distinct seasons of leaf activity. For severity upon plant growth

the dry season does not, of course, compare with a winter in the northern United States, but it does provide a time in which conditions are reduced very much below the optimum, at least for herbaceous growth, and plants not adapted to endure this season of slender supply do not thrive in the monsoon forests.

Another factor goes perhaps even further than the unequal distribution of rainfall in determining the lack of striking luxuriance in these forests. This is the great rapidity of organic decay, which must be considered a factor of prime importance in determining the conditions of plant life throughout the islands. It is a fact with which the most transient visitor to the islands is perfectly familiar, exemplified as it is, especially in the rainy season, by the moulding of leather and wool, or by the rapid decay of wooden buildings. This rapidity of decay is clearly indicated by the infrequency of fallen logs in the forests. On account of the frequent high winds and open exposure it would be natural to expect to find numerous wind-falls in these forests. Exactly the opposite is the case. In the majority of the few wind-falls encountered the condition of the foliage indicates the recent date. The woody parts of fallen trees decay and disappear with amazing rapidity. When one remembers the frequent cases of old logs lying

on the ground year after year in the wood lots of the United States, showing signs of rot only very gradually, it appears almost incredible that here the dead, moist wood in the forest should rot away almost as rapidly as leaves wither. Slight consideration will make it obvious that such a condition makes impossible the formation of a rich humus, an element which is characteristic of the great majority of our American forests and to which their comparative luxuriance in undergrowth is largely due. Humus is nothing more than the half decayed debris of the forest floor. Fallen leaves, branches, and logs go to make it up. Of course it is very rich in semi-decomposed organic compounds and furnishes the richest sort of feeding ground for the herbaceous forms which cover it. Further, it gives up very slowly the water which soaks into it from rains, supplying herein an important physical aid to the life of the smaller plants which thrive upon it, in addition to the rich supply of nutrient material. The almost complete lack of this humus is one of the most striking characteristics of our upland monsoon-forests. Scrape away a thin coating of recently fallen leaves and the subjacent soil, usually a reddish, rather coarse clay, is immediately exposed. This soil is almost completely inorganic; that is, it has come almost entirely from rock rather than

vegetable decay, and herein lies a large part of the explanation of the absence of luxurious herbaceous growth in these forests. Indeed it has been observed in the forests of Bataan and Mindoro that, aside from the reproduction of the trees themselves and the presence of ferns and their allies, the undergrowth, save in clearings, forms a remarkably low percentage of the total vegetation.

One more factor remains to be considered which operates largely to limit the luxuriance of these forests and to bring them nearly on a par with our American forests in that particular. It is that they are very largely ridge and upland rather than valley forests. Not only is this a character to be considered in connection with the more rapid drainage which it engenders, but also in connection with both the physical and chemical general characters of the subjacent soil, which are to be predicted from it.

It would probably be fair to say that the dry season combined with the great rapidity of decay, the consequent absence of humus, and the rapidity of drainage, form in these forests an obstacle to luxuriance nearly the equivalent of the winter season in our American forests.

The optimum of luxuriance is to be found where the optimum of growing conditions for

the greatest number of forms is found most nearly throughout the year. Since plants vary as much in the conditions in which they best thrive as they do in the variety of their forms, an ideal of luxuriance for a mixed community of plants never occurs in nature. However, we may expect to find regions in the islands which far more nearly approach that ideal than do these very common monsoon-forests with their numerous limitations.

But the factors which have just been discussed need to be considered in a broader way than from the standpoint of the limitations they place upon rankness of vegetation alone. The fact that the vegetation does not come up to expectation in this particular raises, perhaps, the first question, but, as has already been pointed out in the case of the forests, the explanation does not lie in the fact of a similarity of conditions with those which produce an equal amount of luxuriance at certain times of the year in temperate regions. The conditions which operate upon plant life are radically different; not one whit less different from those of the northern United States, for example, than if the highest degree of tropical luxuriance were everywhere present. It is from the study of all the observable factors which make up these conditions, and a noting, in so far as possible, of their respective effects upon

plant life, that an explanation of the vegetative conditions lies.

Conspicuous among the general factors are:

1. The distinct alternation of wet and dry seasons.

2. The great preponderance of soil resulting from the decomposition of rocks of volcanic origin. (The areas of sedimentary rock are relatively small.)

3. The topographic youth of the islands, i.e., broad old valleys make up far less of the total area of the islands than the uplands. (This predicates both the comparatively rapid run-off of water, and comparatively small areas of alluvial soil. Far more of the soil is lateritic than alluvial, that is, it has not been transported from the site of the rock from whose decomposition it originally resulted.)

4. The air temperature conditons. (Both the relative height and the comparative equability of the temperature are to be considered.)

5. The rapidity of decay. (This factor operates both as a limitation upon humus formation, and accelerates rock-weathering and the consequent formation of deep rock soils.)

6. A large group of islands of varying age and size resulting largely from volcanic upheaval. (The presence of deep channels between the islands and the general steepness of the land slopes down to the water edges have operated against the formation of wide spread areas of sedimentary rock in shallow seas, with the single conspicuous exception of the plain of Luzon.

There seem to have been few shallow seas, few geological changes of gentle character.)

Upon each of these points we find almost an antithesis of the conditions which prevail in the mesophytic regions of the United States, i.e., the regions where the water supply is intermediate between swamp and desert conditions.

CHAPTER IV.

SUGGESTIONS FOR TEACHERS.

Courses in nature study have been conducted with good results in the Normal School at Manila. In how far subjects from nature have been used by American teachers as a medium in teaching English there are no facts in hand to determine. The results at the Normal School, however, warrant the belief that a liberal use of such subjects in elementary discussion is not amiss and is likely to arouse lively interest. The phenomena of plant life are altogether the most convenient nature subjects for use in this connection, since abundant illustrative material is everywhere at hand and should in no case be dispensed with.

The plan of presentation herein suggested makes no claim of superiority A dozen others might doubtless be used with equally good results. It is felt, however, that to some teachers, whose previous training and experience has not been along the lines of nature study, a general plan may not be unwelcome. It needs to be emphasized at the outset that no special effort should be made to cover a given amount of work within a given time. The progress of the discussions

will have to adjust itself to the capabilities of the pupils, and in no case should there be expectation of covering more than the most elementary facts. The primary purpose of the work is to call out something like original thought in addition to the practice in speaking English which will be involved.

Having at hand a plant complete in its vegetative parts, root, stem, and leaves, attention should be called to the obvious distinctions between these parts. A sketch of the plant should be made by the pupils. The effort to make the pupil think for himself cannot be begun too early. The question, for example, "What are the roots for?" may well be asked without any preface of explanation on the part of the teacher. The answers "to hold the plant in the ground," in the case of many plants, or, "to eat," both have virtue in them. So it may be brought out directly from the pupils that "to hold up the leaves" is the primary function of the stem.

The teacher should carefully impress the fact that a plant is just as much a living thing as an animal, that the facts of birth, of growth, of death and the need of food are just as real in the vegetable kingdom as in the animal kingdom. It will be more difficult to make intelligible the idea that green plants are able to make their own food, while animals are dependent upon other

animals or upon plants for theirs, but, by free use of illustration, the fact can probably be made clear. To have a correct understanding of what leaves are for, the pupil must appreciate that the roots absorb from the soil a large part of the material from which plant food is made, that the stems transfer this material to the leaves, and that it is in the leaves, in the essential presence of light, that the process of food manufacture takes place. Without such appreciation on the part of the pupils the statement that leaves are "for the light" would have to be taken entirely on faith. The fundamental association of the life of green plants with light, and the fact that the various forms and positions of leaves all represent a relation to the light whereby the leaf-work may be most efficiently performed for the individual plants,—these are facts which may well be emphasized repeatedly. Attention should be called to the effect which the permanent removal of light has upon plants, as, for example, by placing a board upon grass for several days. Variations in the arrangement of leaves and in their form should be studied and sketches made. The study of illustrative material bearing upon the main facts just stated should supply work for several weeks at least. The matter of concrete illustration can hardly be overdone. Any available plants will serve the purpose. Ferns, grasses,

and branches of trees may well be used in addition to the more typical herbaceous forms. The most should be made of the native aptitude for sketching.

The study of flowers will probably awaken greater interest in the pupil than the study of the vegetative parts of the plants, yet this should be made the latter part of the work if there is to be logical sequence. The pupil will readily be able to make the distinction between flowers as temporary and the vegetative organs as permanent parts of the plant. (The shedding of leaves is generally inconspicuous throughout the Archipelago).

In answer to the question "What are the flowers for?" it would not be surprising to get an approximately correct answer without previous explanation on the part of the teacher. The average Filipino boys and girls are naturally no less observant than any others. The opportunity to observe nature at first hand is ever present with them, and the important part which uncultivated plants share in furnishing food to the natives necessarily quickens this observation. That the flowers have to do with the fruits which succeed them the average Filipino youngster is probably well aware, and an answer to that effect could probably be brought out. That the fruits contain seeds, and that these are for

the reproduction of the plant may have to be first explained by the teacher. That flowers, fruit, and seed are associated together in the work of reproducing the plant should be impressed, and the distinction made from roots, stems, and leaves with their purely vegetative functions. The first work should be, as in the case of the vegetative organs, perfectly concrete. The parts of typical flowers should be studied, the class being required to make numerous sketches. If the pupil can be made to distinguish the parts of flowers, *i. e.*, sepals, petals, stamens, and pistil, without specific direction on the part of the teacher, so much the better. The fact that by insect visitations to the flowers the carrying of pollen from one flower to another is secured should be brought out and illustrated. That the transfer of the pollen is an important step in the process of seed formation should be emphasized, but it is a question whether the attempt to bring out the idea that a sex-process is involved would be worth while.

The study of different kinds of fruits form an important part of the work. Abundant material is always at hand. Edible fruits might well be studied first. The numerous winged fruits of the trees and the fruits adapted for floating which are usually found in profusion along the beaches are excellent illustrative material. The fact that

each fruit is specially adapted in some particular way to secure seed dissemination should always be kept in mind. There is good opportunity for stimulating original thought in asking questions concerning particular fruits as to how the great purpose of seed distribution is secured. Opinions should be invited as to what plants have apparently the best plans for securing this end.

The pupil should not be left to believe that all plants produce flowers. Attention should be given to ferns and their method of reproduction by spores produced on the under side of the fronds, and to the fact that in such forms no structure resembling a flower is present.

Finally, the sprouting of seeds in the school-room should be attempted. Large seeds from almost any pod fruit will probably be found most serviceable in this connection. Damp sawdust usually brings on germination more rapidly than soil, but care must be taken against too great moisture which will cause the rapid formation of mould. Grains of corn placed between moist sheets of blotting paper will be found to germinate with great rapidity. Let the pupils sketch first the seeds, then seedlings in various stages of development, calling their attention to the early differeation of roots, stems, and leaves,

and the respective positions which these organs assume.

The teacher without previous experience in nature study may find these directions too general to be followed easily. It should be remembered that in the absence of information as to the average previous training of the American teachers, in the absence of anything like uniformity of facilities or of knowledge of the aptitude to be expected from the classes with their very heterogeneous character, and with great variation in the character of the illustrative material which may be at hand, it would hardly be worth while to attempt specific directions. Indeed the character of such work, as well as the question of introducing it at all, must be settled in the majority of cases by the individual teacher. There is no warrant for stating a given amount of work which a class might be expected to cover in a given time. Certain it is that no effort should be made to make haste, and the results obtained will depend both upon capability of the class in question and the adaptability of the teacher for such work. The great purpose and the success of nature study in the grammer grades of American schools has lain in the effort to induce first hand observations and reasoning about the facts observed. The pupil is apt to take more kindly to work which finds its text out

of doors and away from the printed page, to study which involves things he can handle, things which he sees every day and which have a considerable economic importance for him.

A considerable difficulty appears to lie in overcoming the tendency of the native to learn wholly by rote and without reasoning. The parts which are to be simply committed to memory should be made as small as possible. If, in addition to serving these purposes, it be granted that nature work furnishes as good subject matter as any for the practice of speaking in English, its desirability in the present connection is evident.

CHAPTER V.

THE STUDY OF FLORAL STRUCTURES.

A knowledge of the structure of flowers and fruit and their chief variations is essential to an intelligent appreciation of the division of flowering plants into families, genera, and species. It is chiefly upon the varying character of flowers and fruit that such division is based.

On the other hand, general botanical knowledge is not an essential prerequisite to the consideration of floral structures. Their comparitive study may be both pleasant and profitable when undertaken solely upon the basis of accurate and painstaking observation.

The flower is the most highly differentiated organ of the plant body. It represents in its manifold variations of structure the highest expression of complex adaptation attained in the plant kingdom. The correlations between specific floral structures and the anatomy as well as the habits of specific insects strongly impels reason to rebel against acceptation of the dependence of plants upon the operation of external factors alone for the determination of structures so delicately related to one another and to an animal organism. So wonderful are these floral

mechanisms, calculated sometimes in their structure to the nicety of a hair, dependent for their successful operation upon what would seem at first sight a merely fortuitous combination of circumstances, that it is hard to ignore the impulse to ascribe discernment rather than passivity to the plant in the working out of such a climax of adaptation, however opposed such a view may be to the doctrine of organic evolution.

It is possible then to regard a flower simply as an ingenious mechanism, apart from its broader botanical significance. The various floral types may be taken as separate inventions each seeking, upon a theory of its own, the solution of a similar problem. The ultimate problem is, in all cases, to secure the optimum quality and quantity of seed, though the most delicate adaptations are usually involved in securing the preliminary step of cross pollination.

The importance of using as a basis for classification the characteristics of those organs least susceptible to modification in the variations of environment is apparent. Flowers and fruit are immensely less liable to such modification than are the purely vegetative organs. Hence, the character of leaves, stems, and roots play a subordinate role in the scheme of classification.

A perfectly intelligent idea of floral variation may be gained by first hand observation. A

text book is not essential. Such study should always be accompanied by the writing of descriptions and the making of drawings, at least in outline. A hand lens is an invaluable adjunct to the work. In the study of the details of floral structure, the study of freshly gathered material has great advantage over that of dried specimens in the herbarium. In the latter case the flowers must be boiled in alcohol to restore something of their original form before they are dissected. Notes upon the floral structure made from dissections at the time of collection are therefore of very great assistance in making determinations of dried material.

Such work should be begun by the consideration of the parts of a simple and perfect flower. The outer whorl of the floral parts, the calyx, should be noted as to whether it is inserted distinctly beneath all the other parts of the flower or whether it partially or wholly covers the ovary, or swollen base of the pistil, the structure in which the seeds ultimately appear; as to whether it is composed of distinctly separate parts (sepals) or whether the sepals are more or less united, which is common. The number of sepals, their shape, their possible difference in size or shape, their texture, the presence or absence of special structures, as hairs or glands, upon them; these and any other

special characteristics which may be observed should be recorded either by note or sketch, preferably by both. A similar study should be made of the corolla and its component petals. In this structure far greater variation is displayed that in the calyx, and, in corresponding degree, its taxonomic value is enhanced. Irregularity is frequent in the corolla, as in the flowers of orchids and leguminous plants. The coalesence of the petals is very common and the corolla tube thus formed must be laid open for the study of the structures within.

As we approach the center of the flower the importance of these structures in forming a taxonomic basis increases. The character of the stamineal whorl or whorls must be known with absolute accuracy before determination of an unknown plant is possible. As has been stated already, the stamens and the carpels, which latter are usually united into the pistil, form the essential organs of a flower. The calyx and corolla may be wholly wanting, and yet the function of seed manufacture be quite as perfectly performed. It should be noted that some plants, commonly trees, bear two kinds of flowers; in one of these the stamens are functional while the carpels are abortive or

absent, in the other, the reverse. In such cases both kinds of flowers need to be collected and studied to form a basis for determination.

The stamineal whorl is apt to be doubled. Where there may be five sepals and five petals there are very commonly ten stamens, and slight scrutiny will reveal that these are in two distinct whorls as to their insertion. Commonly the stamens of the whorl next within the corolla are inserted alternately with the petals or with the lobes of the corolla if the petals be united. It is important to determine whether this is the case or whether, as occasionally happens, the insertion of the stamens is opposite that of the petals. The stamens may be inserted, not at the base of the flower, but directly upon the corolla tube. In such case the point of insertion, whether near the top or toward the base of the tube, should be noted. The stamens may be of irregular length. Their length should be compared with the length of the corolla or its parts. Occasionally the stamens will be found coalescent. In one large order well represented in the tropics (Columniferae) this coalesence includes the pistil as well; the commonly cultivated Hibiscus is an example. Important variations in structure are shown by the individual stamens. The filament or stem-like part of the stamen is often

clothed with fine hairs; it may show a color quite distinct from that of the corolla; it may be short and stout or long and slender. The anther, the structure at the top in which the pollen is borne, may be related in several different ways to the filament. Commonly it lies in the direction of the filament, borne either distinctly at the end or more or less confluent with the filament; the filament may join the anther in the middle of the latter structure and the ends of the anther swing free; the filament may be variously distorted to bring the anther into special relations with the tip of the pistil or with the possible insect visitor to insure the contact of the latter with the pollen, or the end in view may be to insure against close pollination (the deposit of pollen from the anther of the same flower upon the stigma or pistil tip). While many flowers appear to seek close-pollination, evidence clearly indicates that cross-pollination, like cross breeding, generally secures a greater strength of stock. The simplest provision against close-pollination is the maturing of pollen and stigma at different times.

Care and patience are requisite in the study of the innermost of the conspicuous floral organs, usually called the pistil. It is here that the aid of a hand lens, or, preferably, a dissecting

microscope is almost indispensable, at least in the case of small flowers.

Confusion arises in the use of the word "pistil." Interpretation of the floral structures should be based primarily upon an appreciation of the general comparative morphology of the flower; that is, the correspondence between its parts and other parts of the plant. This is especially needed for an understanding of the structure called the pistil. Morphologically considered, the flower is composed of whorls of specially modified leaves originating from a much contracted axis, the floral receptacle. Often the receptacle is little more than a flattened surface at the top of the flower-bearing stalk or pedicel. In the least highly differentiated flowers the whorled character of the floral leaves (sepals, petals, etc.) does not appear. The parts are spirally arranged, as foliage leaves are upon a stem, and their morphological equivalence to leaves is more apparent. (The buttercup and water-lily afford familiar examples. The whorls are often made difficult to distinguish by a splitting and multiplication of the parts. Especially is this true of the stamens, as in apple blossoms, when a first glance would suggest their spiral or irregular arrangement). As we approach the more highly differentiated flowers in which the parts have departed furthest from

resemblance to leaves, the whorled character becomes more and more pronounced and high adaptation to specific floral purposes is shown by the frequent coalesence of parts, thus quite obscuring their foliar character. Such coalesence is conspicuous in flowers like the morning-glory, whose corolla is not made up of separate petals, but the petals are united into a tube or bell form.

It is in the pistil, however, that the coalesence first appears. The very great majority of familiar flowers have their innermost whorl of leaves, the carpels, (analagous to sepals, petals and stamens) united into a single structure to which the term pistil has given. Flowers which display separate carpels, as the buttercup, have been described as having many pistils. It becomes obvious, then, that the term "pistil," though convenient, has no definite morphological value, since it may be applied to several united carpels or to each one of a separated set of them. For morphological accuracy, the flower should be regarded as being made up as follows:

1. The calyx composed of sepals.
2. The corolla ,, ,, petals.
3. The androecium (male group) composed of stamens.
4. The gynoecium (female group) composed of carpels.

The study of the gynoecium, then, is usually the study of a single structure formed by the complete growing together of the carpels, whose individuality can only be ascertained by examination of the internal arrangement. The typical gynoecium is divisible into three distinct parts, proceeding from from base to apex.

1. The ovary or usually enlarged base. A cross section of the ovary displays the structures from which the seeds are ultimately developed, the ovules, and usually reveals the number of the component carpels by the separate chambers into which the ovary is divided.

2. The style is the narrowed portion of the gynoecium which extends upwards from the ovary. It is commonly slender, its obvious function being to enable the uppermost part of the gynoecium, upon which the pollen is to be received, to attain a favorable position for pollination. In some plants, in which the top of the gynoecium is readily accessible to the pollen, the style may be entirely lacking, and the expense of the development of of a long pollen tube, which is essential when the nuclei of the pollen have to traverse an extended style, is saved.

3. The stigma is that part of the gynoecium which is adapted for the reception of the pollen. It commonly takes the form of a slightly expanded pad at the top of the style and is coated by a somewhat sticky secre-

tion. The stigma does not possess a definite morphology. It assumes a great variety of forms, its function obviously calling for no consistency in structure. It is common to speak of the "stigmatic surfaces."

The great importance of a knowledge of the details of the gynoecium for determining the genus and species of a plant has already been mentioned. It is obvious that such knowledge can be gained with much greater ease in the examination and dissection of fresh than of dried material. It is highly desirable, therefore, that the collector should make descriptive notes and careful sketches of the parts described above. Especially important to determine are the number of chambers or cells of the ovary, the number of seeds in each and their method of arrangement, whether they are borne from the sides or center of the ovary. A careful sketch of a cross section will usually reveal these points.

When the study of the structure of flowers, becomes comparative, and an appreciation is had of the immense variety of adaptation to secure the common ends in view, it becomes possible to definitely realize the broad kinships of families and orders indicated by similarities in these comparatively intimate structures.

CHAPTER VI.

VEGETATIVE AND REPRODUCTIVE PERIODICITY.

The great dominant characteristic of the American forests is their deciduous character. The appearance of the first leaves and their gradual maturity in the spring months, their uniform vigor throughout the summer, marred only by an occasional drouth, their loss of dark green leaf color and the coming on of autumnal tints with the frosts to tree and shrub alike, the loss of foliage and the long period of vegetative inactivity during the winter months; these are the conspicuous features of the vegetation around him with which the home bred American, outside the desert and semi-tropical States, is most familiar.

Do we find in tropical regions anything which corresponds to such marked periodic changes in vegetative life? Is there any rotation of seasons in the Philippine Islands with such profound effects upon the plants?

One of the fundamental facts of plant as well as animal life is that, under whatever conditions it may exist, it alternates in periods of greater and less activity, *i. e.*, periods of work and periods of rest. However propitious external

conditions may continuously be, the period of rest is inevitable. The late Dr. Schimper, one of the foremost of German authorities, goes so far as to write:—"The rhythmic alternation of periods of rest and activity is always present, for it is involved in the fundamental nature of the organism and does not depend upon external factors. Its relation to the latter is a secondary phenomenon, and adaptation."

Certainly we do not have in the Philippines any such conspicuous correlation of the alternating periods of rest and activity with changes of season as is evident in temperate regions. Yet we do not find a total independence of seasons in the occurrence of these periods, for very many plants show a conspicuous shedding of leaves in connection with the dry season. It should be emphasized, however, that a loss of leaves during the dry season is not to be considered the equivalent of a loss of leaves during winter in indicating that the plant is in a state of rest. The winter cold operates more than the absence of leaves in enforcing rest upon the plant. In the dry season, on the other hand, aside from leaf work, the activity of the plant may be as great as ever. A plant stripped of leaves is by no means to be considered from that fact alone to be in a dormant condition. Very many functions, not so conspicuous, but equally fundamental in

the economy of plant life, may be conducted with more vigor on account of the absence of the leaves unless checked by some factor like the cold of winter in effect.

There is a popular impression with reference to tropical forests in general that they are evergreen and that the regions in which they occur are regions of constant moisture. Often associated with this erroneous conception is the idea that the dry season has little or no effect upon the forests. The fact is that trees which have conspicuous periods of foliage-loss are far commoner in tropical forests than those which are evergreen.

The causes which induce the periods of foliage-loss are apparently various. The single conspicuous factor is the dry season, but this is by no means universally effective. Some trees suffer no apparent diminution of foliage on account of the dry season, but shed and renew their leaves quite independently of it. Others, in regions where a dry season is not distinctly marked, undergo periods of foliage loss which may not with certainty be referred to any external factor as an immediate cause.

The exact time of the period of loss may vary with the species. Under apparently equivalent external conditions, some trees lose their foliage before the rainy season has come to an

end, in others the loss occurs at the beginning of the dry season. In some the loss is gradual, extending through several months, while others retain their foliage even as late as the unfolding of the new leaf buds. According to Warming, the foliage-loss may, in some trees, be entirely omitted in certain years. Such variations occur especially in regions where the dry season is not very long or very marked. In tropical regions of very slight climatic periodicity, many trees shed their leaves from one to six times a year without apparent regard to external conditions nor in conformity within species-limits. Trees of the same species under the same conditions may lose or retain their foliage at totally different times.

It must not be understood that those tropical trees which are evergreen do not renew their foliage quite as often as the forms which are conspicuously bare at certain times. The evergreen character simply involves the fact that the resting-buds unfold and the new leaves appear as fast as the old leaves drop off and, since this process does not occur for the whole tree at the same time, but may spread gradually from branch to branch, the general aspect of the tree remains practically unchanged.

Aside, then, from the partial loss of foliage in connection with the dry season, the periodicity

in plant activity in the Philippine Islands may not be readily assigned to external causes.

Next to the periodic loss of leaves, dependent or independent of external conditions as it may apparently be, the periodic appearance of flowers and fruit is the most conspicuous evidence of the habit of periodicity on the part of the plant. Here we find the widest possible range of variation in Philippine plants, with the causes difficult to ascribe. No season is especially conspicuous as a flowering season, as are the spring months in temperate regions. The time of flowering, like the time of leafing and unleafing in the apparently irregular forms which have been described, appears to be often a matter of individual caprice.

It may be accepted as a general rule, however, that the unfolding of leaf buds and the development of flowers do not occur together. Usually these processes are separated in time; sometimes, however, one process may occur in one part of a plant while the other is active in another part. Further, it is the rule in herbaceous plants, aside from those which develop from bulbs, that the flowers appear only after the leaves are nearly mature. Here it is evident that the activity of the leaves must first be attained to supply the food material from which the flowers are built, but in

the case of shrubs and trees, which have considerable supplies of reserve food, there is no such necessity.

As in the case of foliage periods, it may be said of the flowering periods that they show increasing independence of the seasons in proportion as these tend to be similar in character. In tropical climates, equable both as to rainfall and temperature, the periodicity attains the highest degree of independence and of variation. Under such conditions the time of flowering may, of course, be indefinitely protracted, though the common statement that certain tropical forms "bloom the year round" is generally incorrect. Nor does such independence in periodicity, or rather, the constant presence of conditions which permit flowering, necessarily involve a protracted flowering season. The season in such forms may be of no longer duration than in those whose flowering is permitted by climatic and other conditions only within narrow limitations of time. Of course, in the former case, the time of flowering may occur, and usually does occur, more than once a year. It is interesting to note that some of these forms, which combine a short flowering season with apparent indifference to the time in the year of its occurrence, often show a far greater unanimity among themselves than might be expected. Sometimes this is so marked that

forms of this character covering considerable areas come into bloom on the same day.

Forms whose flowering-time is protracted as well as indifferent to season show striking variations of the period within species-limits. It is common to find a tree form of this category in the height of bloom while a near-by individual of the same species may show no trace of flowers.

It becomes evident that in a region in which the conditions just described are to be expected one time of year cannot be said with certainty to have great advantages over any other from the standpoint of the collector. Certainly there is no season in which many forms may be not found in flower. In the regions where the dry season is accompanied by considerable loss of foliage it may be expected that the forms which so suffer will not be in flower during that time, yet exceptions to this rule would not be surprising.

CHAPTER VII.

PERIODICITY IN WOOD FORMATION. *

In regions marked by a distinct annual rotation of seasons, there is no better evidence of the regular periodicity of plant activities than is shown in the cross section of a log. Here we find the wood marked by distinct concentric rings. Microscopic examination reveals the fact that these rings are due to the juxtaposition of zones of smaller cells with zones of larger ones. A given ring shows larger cells along the inner circumference and a gradual reduction of the cells to smaller size toward the outer margin, where the next ring is distinctly set off by the beginning of larger cells again. The explanation of this condition lies in the fact that the growth of true trunks in diameter is due to the activity of a narrow zone of cells lying immediately beneath the bark, called the cambium. When the cambium first begins its

* The pages upon periodicity in wood formation are inserted not so much as a proper part of the text, as by way of illustration. Arguing from known effects of external factors in temperate regions upon a certain feature of plant life, an effort is made to theorize upon the effect of Philippine conditions upon the same feature. The same matter, in slightly altered form, composed a part of an unofficial report made by the writer to the Forestry Bureau.

activity in the growing season it forms cells of comparatively large size. The leaves at that time, in their early maturity, are furnishing an abundant supply of nutrient material. As the season progresses, these cells gradually diminish in size, and those last formed before the long period of winter-rest sets in are usually the smallest. It is this general correspondence of the rings to the annular rotation of seasons that gives value to these rings as evidence of the age of a tree. However, it is not altogether correct to speak of them as "annual rings." A long period of drouth followed by a season of active growing, the irregular destruction of the foliage, as by caterpillars, hailstorms, etc., a severe frost following the early activities of the cambium; these and other factors may result in the formation of more than one ring in a year. It is difficult to distinguish between adventitious rings and the rings formed in the regular rotation of seasons. It is better to call the rings "rings of growth," granting, however, the fact of their usual annual character.

In the consideration of Philippine conditions the question naturally arises whether the annual alternation of periods of greater and less activity of the leaves, where the reduction of leaves occurs only in the dry season, will produce annual growth rings corresponding to those

resulting in such striking fashion from the annual rotation of the seasons in the temperate zones. The bulk of present evidence points to a negative answer. *

Practically all the Philippine woods which have been examined do show rings, but rarely do the rings have the definiteness of those formed in temperate regions. They are rarely complete, and can be more plainly distinguished by the naked eye or hand lens than under the compound microscope where the appearance of demarcation is nearly lost. They fail to show a distinct abutting of large cells upon smaller ones. They are, however, about equally emphasized. If their annual character be supposed, they indicate a very much slower rate of growth than the general environmental conditions unite in indicating; in fact, assuming the annual character of these rings, it would be found that the rate of growth is very much slower than in the great majority of the trees of temperate regions.

Now if the annual alternation of the wet and dry seasons be accepted as the only factor inducing rings, by virtue of the checking of growth during the latter season, the annual character of these rings would be corrolated. If, on the other hand, we accept the idea that a number of these

* "In the wood of tropical plants the annual rings may be entirely absent." Strasburger, Lehrbuch.

rings are formed each year, retaining the idea of the dry season as the most conspicuous causative factor, and explaining the "extra" rings by the exigencies of irregular conditions, we would yet expect the ring formed by the regular dry season to be, as a rule, the most conspicuous, or at least the most perfect of the rings of a given year. Since we find no such evidence, and do find a striking similarity of strength in the rings, whether perfect or imperfect, we are led to the conclusion that the idea of a dry season as a ring-forming agent is inconsistent with the idea of the formation of more than one ring per annum. The facts suggest that the relinquishing of the former idea is preferable to the relinquishing of the latter. However, in the acceptance of the latter is involved an explanation of why the dry season with its inevitable reduction in the manufacture of nutrient material, which goes hand in hand with loss of leaves, may not induce rings. A comparison with conditions in temperate regions with well defined rotation of seasons may serve this point.

In the northern United States, for example, the fall of leaves in autumn is accompanied by a decided lowering of the air-temperature. Whatever fall of leaves may occur in connection with the dry season in the forests under consideration it is marked by no such reduction. A slight

decrease in the average register of temperature may be expected at this time, but not enough to have material effect upon plant activities. The average fall is from 27° C. in the months of heavy rains to 26.30° C. in the dry months.

Now in temperate regions it is the checking of the circulation of solutions of the elaborated nutrient molecules which directly arrests the activity of the cambium ring after the first frosts set in in autumn. The fall in air-temperature is the most directly operative factor in checking this circulation. The fall of the leaves necessarily limits the supply of such nutrient molecules inasmuch as their manufacture is arrested, but there are quantities held in storage which might permit continued activity of the cambium but for the interference with their circulation. In the Philippine forests, as has been indicated, we do not have any conspicuous external factor which would induce an arrestment of the flow of nutrient material and which is at the same time coincident with the fairly general loss of foliage, complete or partial, induced by the dry season. Thus we may assume the possibility that the cambium suffers no striking diminution of its activity directly after the shedding of the leaves. However, even accepting the empirical assumption that the loss of leaves is not followed by any sudden diminution in the size of the cells pro-

duced by the cambium, the point is not yet established. It remains to be shown why, with the early maturity of the new leaves, we may not get a demarcation in the wood cells by virtue of a sudden increase in activity of the cambium and consequent abutting of new larger cells upon older smaller ones, as results from the maximum of mature leaf vigor in the late months of spring in temperate regions. Three factors help toward the conception of such a possibility:

1. The period of reduced foliage is much shorter in the former case than in the latter.

2. External physical conditions give equal if not better warrant for the belief that the cambium is active during that period rather than idle.

3. The loss of old leaves and the appearance of new ones very frequently occurs in tropical forests (the rule in those of equable humidity) without any apparent relation to conspicuous external conditions. Inasmuch as the act of leaf-shedding may appear to be independent of relation to external factors, it has been argued by Schimper that the phenomenon is to be explained by the inherent tendency of organisms to establish periods of rest in the various members irrespective of physical conditions where these are comparatively constant.

"Observations in tropical regions with considerable rain throughout the year have made it evident that the vital processes have a rhythmical alternation of periods of rest and activity... The

time of rest does not occur at the same time for all the processes, but only for certain functions... The less decided the periodicity of the climate, the more independent of it is the periodicity of the plants... In all tropical regions with very widely marked climatic periods there are woody plants which shed their foliage at longer or shorter intervals (1-6 times a year) and without reference to the season. Trees of the same species under the same external conditions may lose and renew their foliage at different times from each other." (Translation from Schimper's Pflanzengeographie.)

In other words, an alternation of rest with labor is inevitable on the part of any given vegetative organ even if the physical surroundings are constantly at the optimum for its activity. If the argument be applied to the cambium, under the assumption already advanced that the short period of reduced foliage has no greater claim to be its period of rest than any other, we are strengthened in the idea that the optimum conditions of food manufacture, *i. e.*, when the leaves have attained their greatest efficiency and have ceased to draw upon the output of nutrient material for their own growth, may not induce the optimum of activity on the part of cambium. If, indeed, it can be established that under ordinary healthy condition the supply of nutrient material which

may be drawn upon by the cambium is, in the forms under consideration, at all times equal to the demands of the cambium in its maximum of cell manufacture, then we have established that the cambium may be perfectly independent of either the loss of foliage or its renewed activity in its rhythm of greater and less activity. Such a view is consonant with the following facts, while the application of the law of annual rings in connection with the annual alternation of wet and dry seasons and the correlation of foliage loss with a suppression of cambium work is strikingly at variance with them:

1. That the rings in the timber under consideration are of equal strength.
2. That they are generally imperfect and indefinite in character.
3. That the formation of but a single ring in a year is highly improbable, the formation of several being the reasonable expectation.
4. That they are close set.

That rings may result under tropical conditions independently of obvious external conditions, and may be apparently dependent upon the inherent tendency of the cambium to alternating periods of greater and less activity, is then the hypothesis to which our argument tends. Against the contention that evidence of such a condition, if true, should be apparent even in the trees of temperate regions, the long period of rest

enforced upon the cambium by the checking through frost of sap circulation, may be strongly urged.

Under the conditions of the hypothesis the following provisional conclusions arise:

1. That the general annual character of the rings in Philippine woods is disestablished.

2. That no regularity in the time required for ring formation in different forms may be assumed; that a broad range of variation in the time is to be expected.

3. That the rings will be more clearly defined in the earlier formed wood than in the later.

4. That the possibility of the habit of ring formation in some forms in conformity with obvious external variations of conditions or with the seasons is not excluded.

5. That no general rule whereby dependence may be placed upon the number of rings as a criterion of age can be attained.

Recent field observations indicate that the loss of foliage during the dry season has probably even less effect upon the general activities of the plant than was assumed in the foregoing paragraphs. It has been observed that in the large majority of trees in a mixed area the foliage-change occurs gradually. Before the shedding of the old leaves the buds of the new ones were ready to unfold, and the reduction in the amount of active leaf area during this period is slight.

A few species did show a simultaneous loss of the old leaves and were in some cases as long as a fortnight almost as bare of foliage as the deciduous trees of temperate regions in winter.* Even in such cases, however, the unfolding of the new leaves is so rapid that it is safe to assume the direct effect of such transitory foliage loss upon the activities of the cambium is not very considerable. It would be reasonable to suppose that the effect of accidental destruction of foliage during the growing season in temperate regions, as by late frost or continued drouths, would be considerably greater. The recovery of the plant when favorable conditions are restored would naturally be much slower in the latter case on account of the immaturity of the leaf buds. So far as the temperature factor is concerned, it might reasonably be urged that the foliage loss in the dry season, at least for those forms whose leaves fall simultaneously, would have as much effect upon the cambium as such accidental losses of foliage as have been cited for temperate regions. It appears to be clearly established that such accidental losses may result in definite growth rings. Such argument would go far to overthrow the most important conclusion to which the present writing tends, were it not reasonably answered in the manner indicated.

* A few leguminous forms stand without foliage as long as two months and these cannot be considered in the present argument. These forms do show regular rings, which it would be reasonable to suppose are of general annual character.

CHAPTER VIII.

ECOLOGICAL FEATURES.

The ecology of plants may be roughly stated as a study of their social relations. It has been defined as the consideration of the mutual relations between plants and their environment. It is plant sociology. Ecology regards the plant kingdom not as a static thing, but recognizes it as a realm of constant change. It seeks to explain how the perpetual changes in environmental factors affect plant life, therein throwing light upon the whole process of organic evolution. Just as the most complex sociological problems are to be found in crowded cities, so the luxuriance of plant life within the tropics furnishes the greatest complexities in ecology. Here again the Philippines afford a rich field for the interpretation of unstudied conditions.

From the standpoint of their ecological relations plants may be variously divided into groups. Taxonomy, or the classification of species, regards a form quite apart from its environment and puts it into a certain category upon the basis of its structural features, finding distinctions enough in the varying form of plant organs to create an enormous number of

distinct species. Ecology cannot regard a plant apart from its environment. Its classifications must be upon the basis of features of the environment. Its distinctions depend upon environmental effects.

Inasmuch as the relation to water is the external factor having the most conspicuous effect upon plant life, a division upon the basis of variations in that relation is the most important ecological classification. Thus we have xerophytes (desert-plants) which live in the presence of a very slender water supply, hydrophytes (water-plants) which may be submerged in water and are at least always in the presence of a great abundance of it, and mesophytes, which occupy conditions intermediate between the xerophytic and hydrophytic states. It is obvious that the great majority of plants fall into the mesophytic category.

Another broad ecological classification might be made upon the basis of the light relation. Plants show conspicuous variation in habits of relating their foliage to the light. Here again there are three distinct categories. (1) Plants which seem unable to obtain too much light and whose leaves are placed to secure a maximum of illumination. (2) Plants accustomed to grow in conditions of strong illumination, but whose structure indicates an avoidance of the direct

rays of the sun. (An avoidance which the dangers of too great heat and radiation probably contribute to establish.) Conspicuous in this category are the grasses, whose usually vertical blades are adapted to avoid rather than to seek intense illumination. Wherever equitant leaves (vertical leaves, usually narrow) are to be seen they may be taken as an indication of this habit. (3) Finally, we have a considerable category of plants with comparatively large thin leaves whose normal habitat is seldom if ever visited by intense illumination. Such forms may nearly always be found in the dense shade of the forest or in deep ravines. Their structure adapts them perfectly to the use of the diffused light in which they thrive, but they would very speedily succumb to continuous direct illumination. The latter category may be distinguished as ombrophilous (shade-loving) in distinction from the former two which are ombrophobous (opposed to shade).

Another ecological classification which is rarely attempted, but which is of great significance, finds its basis in the relation of plants to topography. The history of the vegetation of a particular area will find its beginnings sometime subsequent to the time when the area in question became land, either by the withdrawal of the sea or by an upheaval. Here we would

have at the very first a land area unmarked by the effect of the great erosive forces,—rock weathering, the wear of water in rain and streams, etc.,—which are constantly at work in reducing all land areas to an ultimate level plain. Gradually these agents would produce their inevitable effects. Valleys would appear. The rock more resistant to the erosive forces would assert itself in peaks and ridges. Areas covered by the alluvial deposits of the streams would be established. Gradually the "base level" is approached.

It becomes evident that this great cycle of changes will have a profound effect upon plant life. The effects of a hill and ridge region upon the forest which covers it, as contrasted with the effect of a region whose topography indicates greater advancement in the erosion cycle, have already been touched upon.

It is because the effect of this factor upon plant life is illustrated on every hand in the Philippine Islands that it is emphasized in a connection which does not permit full discussion. There are in the Archipelago hundreds of small islands which may be loosely characterized as being topographically very young. Here we find xerophytic conditions almost universal. The conditions of drainage are usually very rapid and scant opportunity is

afforded for soil formation. On islands of greater topographic age are numerous young valleys. It is possible to make a certain correlation of the vegetation with these conditions. On some of the larger islands broad valleys occur and here is evident the inevitable correspondence of the vegetation with the slow moving but, in the absence of land elevation, ever progressive series of topographical changes, and consequent effects upon the soil.

These considerations of ecology with reference to the physical factors which broadly control plant life need to be appreciated as a preface to the study of specific plant adaptations. These, however, may find their explanation largely in the relations of plants to each other. A general analogy with contrasting effects upon human society is permissible. In sociology we have first the broad effects of physical environment to consider, then the more complex effects of the relations between individuals and classes of society.

AN ECOLOGICAL ASPECT OF A FOREST.

Plant, like human, societies are characterized by dominant classes. In a Philippine forest of the monsoon-type, such as that described in Chapter III, the dominance clearly belongs to the trees. One working classification in consi-

dering the ecology of such a forest might be made on the basis of the strata of the vegetation. Let the first stratum include the ground-cover, plants which rise no more than two feet above the surface. Plants limited to this altitude have a precarious existence under the conditions (absence of humus, shade, scanty water supply in dry seasons, etc.) already described for such a forest. Save in occasional clearings, few grasses thrive. Ferns, and their allies, chiefly members of the genus Selaginella, are the most successful forms coming within this limitation. Quite as frequent in total display, but less successful, are the tree seedlings. (It is in the seedling stage that the trees under these conditions have the hardest struggle for existence. A very small proportion of the seeds which germinate survive this stage, and yet, so great is the over-productiveness of nature, that the supply of thrifty seedlings is usually quite large enough to take advantage of what opportunities exist for the development of young trees in an already densely populated forest. The greater activity of certain seedlings to thrive under shade conditions often determines which shall be the ascendent, which the declining types in a forest). In this zone are also found occasional monocots, chiefly lilies and orchids, and species of Begonia are very common; all shade-loving forms. Thus, ferns, lilies, and

tree seedlings, exceedingly different forms in structure and widely separated in ordinary classification, fall here in a common ecological category in that they are living together in a similar environment. They form a distinct class in a plant society.

In the next stratum, forms not exceeding fifteen feet in elevation may be considered. Most conspicuous here are the tree saplings, while a considerable number of large shrubs (species of Mussænda, Tabernæmontana, etc.) are successful where the shade is not too dense. Occasionally thrifty groups of Pandanus (screw-pine, so called from the resemblance of its fruit to the pineapple), a very simple monocot, appear near the courses of the rapidly flowing streams.

In the upper stretches limitations are not so easy to make. The trees of lesser altitude are not always clearly demarked as a class from the taller ones. Frequent gradations may be found. Yet it may be said of monsoon-forests in general that they are apt to be "two-storied." The height of the bulk of the trees is less than 100 feet, while a considerable number of species commonly run above that height. Of the trees collectively it may be said that they possess tremendous advantages over the forms of other zones in the display of foliage to light, while success in the keen competition which is going

on among them seems to depend more upon marked reproductive capacity than upon mature altitude. By reproductive capacity is meant not merely a prolific formation of seeds, but rather the ability of the seedlings to withstand the hard conditions of shade and occasional drouth to which they are subjected and to come to vigorous maturity. Thus members of the family Dipterocarpeæ, characterized by their large winged seeds, have obtained a marked ascendency in many Philippine forests. These are forms which come in the upper zone, above one hundred feet. It needs to be remembered that, in the development of a tree from the seed, it passes successively through all the zones. At different periods of its development it belongs to different ecological categories, nor are these categories limited to those based upon the altitude of foliage display alone. Conditions which are excellent for the mature tree may be prohibitive for the seedling. Very often mature, successful trees are found in considerable abundance without any evidence whatsoever of their reproduction. The conditions which once permitted their own development as seedlings have been altered. New factors have come in or old ones have been lost so that now, while their own mature vigor is in no way imperilled, the success of the seedlings is prohibited. They form a waning type.

Less commonly may be noticed conditions in which seedlings and saplings thrive in the absence of the parent tree, the seeds having been transported. Here we have an ascendant type; unmistakable evidence, as the other, of the changing face of nature.

In every forest, and very conspicuously in tropical forests, occurs a general class of plants which are independent of classification on the basis of the altitude which they attain or the zone in which their foliage is displayed. These are the epiphytes. Used in the broadest way, the term may be applied to any plants which grow upon other plants. Parasitism is as conspicuous in the plant as in the human realm. Epiphytes may be variously sub-divided. Technically the term is limited in application to those forms which obtain merely mechanical support from the plants upon which they grow and have no root connection with the ground. Conspicuous in this category in tropical forests are the epiphytic ferns and orchids; in forests of temperate regions, mosses and lichens. The epiphytic ferns are commonest on horizontal branches and at the points of emergence of the branches from the trunk. Here they form great nests. They usually do not appear until other epiphytes or the supporting tree itself has furnished a foothold for them

by the accumulation in these points of lodgment of an amount of semi-decomposed organic matter. With such footholds the ferns rapidly develop, clustering together the products of their own decay with all else which is available to give a feeding ground and hold-fast for their own roots. Epiphytic orchids, on the other hand, are commonly independent of the usual process of the absorption of the nutrient material in solution by the roots. Their roots may have the unique ability to absorb nutrient material in gaseous form from a moisture laden atmosphere. Such roots have a sponge-like devolopment of tissue at their tips called the velamen.

Another group is formed by the climbers and lianes. The seeds of the former germinate on the ground and, as their name implies, they seize on the first available erect growth and climb to a position in which their leaves may be displayed to the light to greater advantage. The latter germinate directly upon their hosts and grow downwards as well as upwards, usually taking root in the ground. The lianes are made conspicuous by their free strands often hanging like ropes from lofty branches and stretched, when they have taken root, as tight as a bow string.

Technically the word parasites, in speaking of plants, is limited to those forms which put

out sucker-like appendages and directly absorb nourishment from the tissues of their host. From the standpoint of the host, however, the presence of plants using it for mechanical support alone may have quite as fatal an outcome as the pest of true parasites. The mistletoe, leaf blights, mildews, and rusts are familiar types of this class in temperate regions. Forms like them are to be found in tropical forests, yet they appear to be less common than in temperate regions, rarely ravaging the foliage.

The prevalence of the epiphytic habit is pronounced in tropical forests in which luxuriance makes the struggle for light exposure the greatest problem for the plants. The main trunks as well as the branches of the trees seem to take the part of mere scaffolding burdened to the limit of its capacity in supporting the stems and foliage of dozens of different forms. Advantage is taken apparently of every available inch of space which may secure an advantageous light exposure.

A PLAN FOR ECOLOGICAL OBSERVATIONS.

The study of ecology is more difficult than any other botanical work to reduce to a specific plan. Everywhere the conditions to be considered are so various, the factors concerned usually so im-

ponderable, that each task in ecology needs to work out, at least in detail, its own plan. To the amateur botanist in the Philippines work in this field would probably necessarily limit itself at first to the observation of particular adaptations, with an effort to relate them to some particular feature or features of the environment. A familiar example lies in the special adaptations of flowers for effecting the transfer of pollen from flower to flower by means of the visits of insects in their search for nectar, the insects being unconscious carriers. Here we have an adaptation of very high order. In this case the plant seizes upon an external factor of complex character (insects in their search for food) and uses it in the accomplishment of one of the important functions in connection with reproduction. This particular adaptation reaches high complexity in the orchids, whose conspicuous floral irregularity finds an explanation therein.

It is usually easier to explain an adaptation of this character, i. e., one in which the plant uses a factor of its environment in the accomplishment of one of its functions, than those which its environment compels. The external factor concerned is apt to be more conspicuous in the former case. Upon such a basis, adaptations may be loosely divided into those which are facultative and those which are obligate in origin,

without, of course, any definite line of demarcation between the two classes. Thus, for example, the fleshiness of the cactus would appear to be an adaptation compelled by the long droughts characteristic of its habitat, and would belong to the obligate class. Conspicuous in tropical forests are trees which bear their flowers and fruit directly upon the main stems. Especially is this true of species of the genus Ficus. Such an adaptation could hardly be referred to either of the classes outlined, although a partial explanation is to be found in the thinness of bark which tropical conditions permit. Thick bark is characteristic of trees which undergo the hard conditions of winter, and the flowers are borne on the tender parts.

Special adaptations for seed dissemination are very common in Philippine forests. Winged seeds are common. They are especially noticeable in members of the family Dipterocarpeæ, which derives its name from this characteristic. The Dipterocarpeæ are usually tall trees. Their seeds are large and heavy, and, dropped from the hand, fall directly to the ground despite the conspicuous wings. It needs to be remembered that the seeds are detached from the tree at an altitude commonly over one hundred feet and, usually, by high winds; conditions which will permit a considerable flight. The woods are full

of edible fruits, an adaptation which seeks seed dissemination usually through the digestive tract of birds. (This fact suggests the desirability of special record of the edible qualities of fruits in connection with collections. The natives use a great variety of fruits for food; many of them are excellent and are quite unknown to civilized markets. The botanist should never forget the horticulturist.) Fruits specially adapted for floating and resistant to decay in both salt and fresh water are found in great numbers along the beaches.

Animal life needs to be considered in its hostile as well as its friendly relation to plants. Protective adaptations against the ravages of insects, especially ants, are often to be found. Certain plants of temperate regions protect their flowers from ant visitations by means of a stem-clasping leaf arrangement in which water is caught and held. The innumerable hosts of ants in tropical forests and their intimate association with the vegetation demands consideration of them as a factor in the environment. It has been stated that the ravages of ants upon foliage in the tropics of the Eastern hemisphere are insignificant in comparison with their wholesale depredations in the American tropics.

Unquestionably the most advantageous as well as the simplest locality for such observations

as have been suggested is along the sea-shores. Here the factors which conspicuously affect the plants are more obvious, and the conditions of the vegetation which they enforce easier to interpret, than in the more complex inland situations. Beginning at the very water's edge, intergrading zones of varying ecological character are usually apparent until the normal inland condition is reached. Any one who has travelled on the inter-island boats has readily observed the difference in general aspect between the vegetation which lines the shores and that in the background. Miles of mangroves *(Rhizophora* and *Bruguiera)*, cocoanut palms sown by nature *(Cocos nucifera)*, and long fringes of the screw-pine or pandan *(Pandanus)* are characteristic of Philippine shores. Closer examination reveals striking differences in the character of the foliage of the shore plants as contrasted with those only a little further inland. One of the factors which induces this condition is plain to any one who has witnessed the effect of a typhoon upon plants along the exposed coasts. Here the vegetation encounters not only the full force of the wind, but is beaten with destructive force by great showers of salt spray, which is far more injurious to tender leaves than the hardest-driven rain. What plants with tender foliage have sprung up near the

shores between the typhoon seasons are destroyed by thousands. Only those with hard tough foliage are able to be the permanent occupants of this rigorous zone.

Intensity of illumination and rapidity of drainage are very apt to be factors which further affect the character of the shore-bordering vegetation. Hence one is more apt to find plants having a general xerophilous character along the shores than in any other general locality in the Philippine Islands.

Among other conspicuous adaptations to be observed along the shores are the very many kinds of seeds and fruits adapted for dissemination by salt water, the special root structures of the mangrove and the pandan which are often covered by the flood tide and exposed at the ebb, the peculiar habit of the former in the germination of its seeds before they leave the parent plant, etc., etc.

Systematic studies of limited areas may be made to advantage where time and inclination permit careful and continued observation. A tract with uniformity of physical conditions should be selected and records made of its vegetative aspect at intervals through whatever period of time can be given. For anything approaching completeness, the observations should continue throughout the year. It is with such work that

the observer may reasonably attempt to be an interpreter. Interpretation is always rash without the background of continued observation. He becomes a naturalist, striving to take into consideration all observable factors which go to determine the face of nature.

If the area selected must needs be of inland character it should not consist of more than two or three acres and should be of easy access. It should represent as un-mixed an ecological type as possible, and the less the luxuriance the simpler the problem. Primarily, such a study would call for record of all of the forms present. Inasmuch as the majority of the higher plants will probably not be in bloom at any given time, it is evident that even the ground-work can be completed only by continuous observation. Upon a given date a collection should be made of all forms found in bloom. Care should be taken against the exhaustion of forms which may be represented by a limited number of individuals, otherwise the collecting itself becomes a disturbing factor. Consideration must be given to non-flowering plants, such as ferns, mosses, etc. Collection of the lower forms should be made if possible at times when the fruiting organs appear, and here a familiarity with the morphology of lower forms becomes almost essential. Sporangia of ferns,

sporogonia of mosses, etc., need to be recognized. The note-book should contain as full a description as it is possible to make of the conditions which in the opinion of the observer may effect the vegetation on the area in question. Note must be made of which forms are represented by a large number of individuals, which are scattering. The explanation of the occurence of scattering forms is apt to fall under one of three heads: they may be merely sporadic, they may be a waning type indicating the earlier prevalence of conditions in which they were dominant forms, or they may be invaders gradually encroaching. The notes upon general conditions may be divided under two heads: first, the physical conditions, second, the organic conditions. Under the first head would be included notes upon the water supply, notes upon the character and depth of the soil, notes upon the light exposure, upon exposure to storms and high winds, etc. Under the second, notes of the effect of the plants upon each other, as the shading by tree forms, obstacles to the germination of seeds of other plants which may be presented by the dominance of certain forms, as by close-growing grasses, etc. Here also would be included the effects of animals, such as the grazing of cattle, etc.

Such studies are recommended not on account of their liability to give return in the way of

record of facts yet unobserved so much as upon account of their peculiar value, if faithfully prosecuted, in stimulating observation and the ability to form conclusions on the basis of careful consideration of the facts in evidence. Judgment must be held in suspense. A hundred questions of why? may suggest themselves without the indication of a clue to a reasonable answer. However, there is no danger in forming hypotheses; the more the better. But conclusions stated with any degree of positiveness are not safe without the ample support of carefully noted facts and without the refuting of other and contradictory conclusions, and the silent evidence of nature may give better proof of this than any amount of textual reiteration. The scientific spirit may be better engendered by careful observations directly upon the subject matter of a science and attempts to formulate conclusions therefrom than by the teachings of any text.

CHAPTER IX.

THE LARGE SUBDIVISIONS OF SEED-PLANTS.

It has already been pointed out that no suitable key for the exact identification of Philippine plants can be made available at present. Even a key to all the families represented in the Philippine flora would go beyond the purpose of the present work. In order, however, to give the beginner a definite idea of the large subdivisions of flowering plants, the present chapter is included. To learn the generic and specific names of a plant without knowledge of the larger groups to which it belongs is, of course, to put the cart before the horse. It is, none the less, a common fault with the beginner.

The most obvious and natural division of the plant kingdom is the division between those plants which produce seeds (and usually flowers) and those which do not. Of the four great groups of plants (three being composed of the non-seed-producing forms), the group of the seed-plants or Spermatophytes is by far the most complex and the most important. It includes practically all the plants which are of economic value to man. The first great subdivision of the Spermatophytes is into the Gymnosperms and

the Angiosperms. In the former group the seeds are uncovered, the pollen coming directly in contact with the ovule, the structure which develops into the seed after the sex-process or fertilization has been completed. Its most conspicuous order is the order of the Coniferae or cone-bearers, of which the genus Pinus (pine) contains the most wide spread forms in the North Temperate zone. Characterized by the presence of "cones" instead of flowers, and by leaves which are usually needle-like and non-deciduous, the members of this order are easily recognizable. For the most part they are tree forms, and are far more successful in the temperate zones than in the tropics. In the Philippine Islands the conifers are represented by only a few species confined to the higher altitudes, such as the mountains of Zambales and Benguet.

The Angiosperms, on the other hand, constitute by far the greatest part of the vegetation of the earth. In these forms the ovules are always enclosed in an ovary. The amateur student in the Philippines may well confine his attention to this great group. Practically all the Philippine trees belong to the Angiosperms, as well as all the shrubs and herbaceous plants, with the conspicuous exception of the ferns and their allies. The group is readily subdivided into two perfectly natural divisions, the Monocotyledons and the Dicotyledons. These names indicate that

the forms to which they refer possess, respectively, one and two cotyledons or seed-leaves. Distinction may easily be made between the two groups, however, without examining the seed. The veins of the leaves of the Monocotyledons are nearly always more or less parallel, while the parts of the flower are commonly in threes, or multiples of three, viz., three sepals, three petals, six stamens, and three carpels. The Dicotyledons, on the other hand, possess netted-veined leaves, while the type number for the flower parts (to which there are numerous exceptions) is five. The Monocotyledons include the grasses, the sedges, the lilies, the bamboo, the banana, the palms, the orchids, etc. The only tree forms included are the palm trees, the Monocotyledons having a very limited power of wood formation. The Dicotyledons form a much larger group, including all the trees except the palm trees and the very large majority of the shrubs.

The following arrangement of the Angiosperms follows the system of the German botanists Engler and Prantl. It is in general acceptance by botanists the world over.

MONOCOTYLEDONS.

ORDER I —LILIIFLORAE. Flowers regular and always possessing a perfect corolla and calyx. The ovary contains three seed-cavities. This large order presents the perfect monocot type of flower, most of the other orders

being characterized either by lack of calyx or corolla or by a lack of radial symmetry. Examples, the lilies and the rushes. The lirio is the commonest of Philippine lilies. Important families, *Juncaceae*, *Liliaceae*, *Amaryllidaceae*, *Iridaceae*, *Bromeliaceae* (pine-apple family.)

ORDER 2.—ENANTIOBLASTAE. Grass-like or herbaceous plants with small, inconspicuous flowers. Often the flowers vary from the perfect type by the absence of some of the parts. The creeping *Commelina* with small blue flowers is common in the Philippines. *Tradescantia* or wandering-jew is much cultivated in the United States. Important families, *Centrolepidaceae*, *Restiaceae*, *Eriocaulaceae*, *Xyridaceae*, *Commelinaceae*.

ORDER 3.—SPADICIFLORAE. Small flowers without calyx and corolla borne close together on an elongated stalk, the spadix. The jack-in-the-pulpit is typical of this order. The flowers are usually of two kinds, one staminate, the other pistillate, the latter being nearer the base of the spadix. One or more large sheathing bracts (spathes) arise from the base of the spadix. The members of this order differ widely in the character of their vegetative organs, but are united by the unique floristic character which has been described. Conspicuous Philippine examples are the palms and the pandan. Important families, *Palmae*, *Araceae*, *Lemnaceae*, (duck-weed family), *Pandanaceae*, *Cyclanthaceae* (includes many tropical lianes), *Typhaceae* (cat-tail family.)

ORDER 4.—GLUMIFLORAE. The order of grasses and sedges. Flowers small, usually naked (*i.e.* without corolla or calyx), ovary containing one seed. Mostly herbs with long and narrow leaves. The inconspicuous flowers occur in clusters and are protected by many

yellowish bracts. Since the pollen is transferred by the wind, large quantities of it are produced, borne in prominently exposed anthers, while the stigmas are extensively developed, often being feather-like. Due to the fact that the ovary contains but a single seed which entirely fills it, the entire ovary is commonly considered as one seed. For example, a kernel of corn is really an ovary containing a seed. Were it a naked seed, corn would properly belong to the Gymnosperms. Here are included the plants of greatest economic value, wheat, rice, corn, sugar-cane, oats, barley, etc. Families, *Cyperaceae* (sedges) and *Gramineae*.

ORDER 5.—HELOBIAE. These are marsh or water plants, sometimes of a grass-like appearance, sometimes with broad leaves. The flowers are regular and corolla and calyx usually both present, but the stamens are usually more than six, and the carpels more than three. The calaboa with its purple flowers in clusters, and its large leaves shaped like spear-heads, is an example which is common in the ditches around Manila. Important families, *Alismaceae*, *Hydrocharitaceae*, *Potamogetonaceae*.

ORDER 6.—SCITAMINEAE. An order which is largely represented in the tropics. The flowers are nearly always showy, and are somewhat irregular. The petals always arise above the ovary. The stamens are reduced in number, and they often resemble the petals, the anther appearing on the margin. The ovary has three seed-cavities. The best known examples in the Philippines are the various varieties of banana and canna. Manila hemp is derived from a member of the banana family. Important families, *Musaceae* (banana family), *Zingiberaceae*, *Cannaceae*, *Marantaceae*.

ORDER 7.—GYNANDRAE. This order, which includes but one family, *Orchidaceae*, represents altogether the highest type of monocotyledons, and presents the most complex flowers in the entire plant kingdom. It is predominantly tropical, and the majority of its species are epiphytic. The flowers are always irregular and highly adapted for insect pollination. The petals arise above the ovary. The androecium is reduced and is united with the gynoecium to form the peculiar "column," or *gynostemium*. The pollen occurs in sticky masses. The ovary usually has but one seed-cavity and contains very many small seeds.

DICOTYLEDONS.

A. ARCHICHLAMYDEAE. — Flowers either without petals or with petals which are separate.

ORDER 1.—AMENTACEAE. A tree group characterized by the arrangement of the staminate flowers in aments or catkins. These are conspicuous on the pussy willow in early spring. The flowers are of two kinds, one bearing the stamens (staminate), the other the pistil (pistillate). Often the staminate and pistillate flowers are borne on different individuals; such species are called dicecious. The flowers are nearly always naked, the number of stamens is variable, and the leaves are opposite. This order is far more successful in the temperate zones than in the tropics. However, it is represented in the Philippine Islands by several species of the oak. The genus *Casuarina*, represented in the Philippines by trees whose foliage gives them the appearance of pines, but whose needle-like leaves are jointed, belongs to a peculiar family which is usually referred to in this order. Important families, *Salicaceae* (willow and poplar family),

Cupuliferae (oak family, including the birch, alder beech, chesnut, etc.), *Juglandaceae* (walnut family).

ORDER 2.—URTICINAE. This order includes forms whose vegetative body shows a wide range of variation. It includes the elms, the india-rubber tree, and the nettles, whose kinship is suggested only by comparison of the floral structures. The flowers are usually of the two kinds, staminate and pistillate, and are naked save for a very simple calyx-like structure. The gynœcium is usually reduced to a single fertile carpel. The flowers occur in thick groups or infloresences. The leaves always have stipules, which are structures, usually leaf-like, at or near the base of the true leaf. Very commonly a milky juice is present. The order is widely represented in the Philippines by the great genus *Ficus*, to which the banyan-tree belongs, and the balete. Species of *Ficus* are often cultivated for ornamental trees. They have large, oval, and rather thick leaves with a very smooth surface. Important families, *Ulmaceae* (elm family), *Moraceae* (fig family, to which *Ficus* also belongs, as well as *Artocarpus*, the bread-fruit), *Cannabinaceae* (including the common hemp and the hop plant), *Urticaceae* (the nettle family).

ORDER 3.—POLYGONINAE. Resembles the foregoing in having small, usually greenish, flowers in thick clusters, but may be distinguished by having the parts of the flowers in threes. Stamens and carpels are usually present in the same flower. The ovary has one seed-cavity, and one seed. Nearly always herbaceous. The pepper plant is a Philippine example. Important families, *Piperaceae* (pepper family), *Polygonaceae* (including dock and rhubarb).

ORDER 4.—CENTROSPERMAE. Includes many common weeds of the temperate regions, such as the pig weed, the poke weed, the purslane, and the amaranth. The

flowers have their parts in fives and usually have calyx and corolla. The ovary is commonly one-seeded. Much commoner in temperate regions than in the tropics. Important families, *Chenepodiaceae* (including the beet and spinach), *Amarantaceae*, *Caryophyllaceae* (the wild pink family).

ORDER 5.—POLYCARPICAE. As in URTICINAE, there are here included herbs and woody plants of very dissimilar appearance whose relationship is revealed only by the structure of the flowers. The characteristic thing, as indicated by the name, is the presence of many carpels which are separate. The whole flower is built on a spiral plan, instead of having the parts in whorls. There are numerous stamens. Here are included in the family *Ranunculaceae* many of the spring flowers of the United States, such as the buttercup, anemone, columbine, larkspur, and meadow-rue. The ilang-ilang (*Cananga odorata*) belongs to the *Anonaceae*. Other important familes, *Nymphaeaceae* (water-lily family), *Magnoliaceae* (sparingly represented in the Philippines), *Myristicaceae* (including the nutmeg), *Lauraceae* (including several Philippine timber trees of which baticuling is the most valuable).

ORDER 6.—RHOEADINAE. The members of this order are clearly distinguished by having the parts of the flowers in twos or fours. The corolla is usually composed of four petals, and the gynoecium of two united carpels. The ovary contains a single seed-cavity. All are herbs with alternate simple leaves. The largest family, *Cruciferae* (the mustard family), gets its name from the appearance of a cross formed by the four petals. The *Papaveraceae* (poppy family) are also included. The order is more common in temperate regions than in the tropics.

ORDER 7.—CISTIFLORAE. An artificial rather than a natural order containing many forms whose systematic position is very difficult to assign. The parts of the flower are usually in fives, but the number of stamens is often increased by division, while the number of carpels may be reduced to three. The ovary nearly always contains a single seed-cavity. The order is notably represented in the Philippines by the family *Dipterocarpeae* which is altogether the most successful of tree families in this region, and includes, among many important timber trees, yacal, panao, guijo, tanguile, and lauan. Several important gums and resins are obtained from these trees, *resina dammar* among them. These forms often attain a height considerably over 100 feet, and are characterized by seeds with large wings, as indicated by the family name. Another notable Philippine member is the mangosteen, which belongs to the genus *Garcinia*, of the family *Clusiaceae*. *Garcinia* also includes a number of timber trees. The tea plant (*Thea Chinensis*), belongs here, a member of the family *Ternstroemiaceae*. Other important families, *Violaceae* (violet family), *Droseraceae* (including the sun-dew. All the members of this family are carnivorous, and have elaborate contrivances for the capture of insects), *Hypericaceae* (includes the St. John's-wort and other common wayside weeds, recognizable by the translucent dots in the leaves).

ORDER 8.—PASSIFLORINAE. A small order of herbaceous plants, largely represented in the tropics. The gynoecium is always composed of three carpels, united as to the ovary, but usually with separate styles. Ovary with one seed-cavity. There is much variability in the number of the parts of the androecium and corolla. The passion-flower is characterized by an exceptional struc-

ture, the corona, which forms a fringe between the corolla and the androecium. The common papaya (*Carica papaya*) belongs to the family *Caricaceae* which is usually included in this order. The begonias are familiar examples which are common in Philippine forests. Important families, *Passifloraceae* (usually climbers with large, handsome flowers), *Begoniaceae*.

ORDER 9.—OPUNTINAE. An order containing but one family, the *Cactaceae*. Its members are easily recognizable by their vegetative character. They are desert plants, without true leaves, and profusely armed with thorns. The parts of the flower are in indefinite numbers. Ovary with one seed-cavity.

ORDER 10.—COLUMNIFERAE. A large and well defined order, numerously represented in the Philippines. The most striking characteristic is the formation of a column by the union of the filaments of the stamens around the style. The stamens are often indefinite in number. Carpels two to an indefinite number and septate, *i. e.*, their separate character is evident. A familiar example is the genus *Hibiscus*, whose various species are the most commonly cultivated flowers in Manila where their bright red bloom is conspicuous the year round. *Hibiscus* belongs to the family *Malvaceae*, the largest of the order. Here also belongs the cotton plant (*Gossypium herbaceum*). *Sterculiaceæ* include dungon, dungon late and other important timber trees, as well as the cacao-tree (*Theobroma cacao*). Other important families, *Tiliaceae* (including the linden or bass-wood) and *Bombaceae* (tropical trees with soft wood and swollen trunks).

ORDER 11.—GRUINALES. This order is distinguished from the preceding by the regular number (5) of the stamens and by the only partial union of their filaments.

Carpels five or less, united, but septate. More important in temperate zones than in the tropics. Important families, *Geraniaceae*, *Oxalidaceae*, *Linaceae* (from *Linum usitatissimum* linen is derived), *Balsaminaceae* (including the touch-me-not), *Polygalaceae* (characterized by somewhat asymmetrical flowers, widely distributed over the whole world, and includes many tropical shrubs and herbs).

ORDER 12.—TEREBINTHINAE. An important tropical order. The flowers are much like those of the preceding order, but are characterized by the possession of a special structure, the disc, which is developed between the stamens and the carpels. It has no special function. The majority are aromatic woody plants with pinnate leaves. The most important family is the *Rutaceae* to whose genus *Citrus* the orange, lemon, grape-fruit, and citron belong. This family also includes several Philippine species from which fine wood for canes and cabinet work is obtained (camuning, lognig, etc.). Other important families, *Burseraceae* (from a species of *Canarium*, elemi, a resin of considerable commercial importance in making varnishes, is obtained in the Philippines), *Anacardiaceae* (includes sumach and poison-ivy).

ORDER 13.—SAPINDINAE. Flowers usually somewhat asymmetrical. Especially distinguished from preceding by the fact that the disc is between the corolla and the stamens; number of stamens usually eight. Woody plants. Important families, *Aceraceae* (the genus *Acer* includes the many species of maple), *Sapindaceae* (contains a number of Philippine species producing medium grade timber; also the familiar horse-chesnut and buckeye).

ORDER 14.—FRANGULINAE. The members of this order are for the most part shrubs, sometimes climbing by means of tendrils. The leaves are generally simple.

The flowers are small and inconspicuous, usually with reduced calyx and greenish or white corolla. They have only a single whorl of stamens, and two to five carpels with as many seed-cavities, one or two seeds in each cavity. Of Philippine genera the most important is *Cissus*, of the family *Vitaceae*. It includes several common vines, which, when cut, yield a large quantity of clear water good for drinking. This family also includes the Virginia creeper, while the numerous cultivated species of grape vine have been derived from *Vitis vinifera*. Other families, *Aquifoliaceae* (includes *Ilex*, the holly), *Rhamnaceae* (buckthorn family).

ORDER 15.—THYMELAEINAE. Here the corolla is reduced or wanting and the ovary consists apparently of one carpel containing one ovule Mostly shrubs with simple, entire leaves, and small flowers. Almost entirely confined to the southern hemisphere. Families, *Thymelaeaceae. Elaeagnaceae.*

ORDER 16.—TRICOCCAE. An order comprising the single family *Euphorbiaceae* (spurge family) which includes plants of the most varied habit whose kinship is revealed by the manner of attachment and structure of the ovule. The flowers are always small and inconspicuous and are usually unisexual, *i. e.*, staminate and pistillate. The ovary is of three carpels with three seed-cavities, and one or two ovules are suspended in each cavity. It is often possible to recognize the members of the order by the three-parted character of the fruit capsule, indicated by the name. The order is represented in the Philippines by a large number of shrubs, lianes, and trees, many of the latter furnishing timber of inferior grades.

ORDER 17.—UMBELLIFLORAE. The order is characterized by the umbel type of flower cluster, in which

numerous flower-bearing pedicels arise from the same point. (The common wild carrot of the United States is an example). In distinction from the preceding orders, the petals always arise distinctly above the ovary, *i. e.*, the flowers are *epigynous*, not *hypogynous*. The calyx is greatly reduced, the gynoecium is composed of two carpels and has two seed-cavities, each containing a single ovule. Herbs or shrubs with small flowers and divided or compound leaves. Families, *Umbelliferae*, *Cornaceae* (dog-wood family), *Araliaceae* (includes a number of small Philippine trees).

ORDER 18.—SAXIFRAGINAE. A small order not largely represented in the tropics. It is somewhat artificial since its members show great diversity in the floral structures. The flowers are small and regular, with the outer stamens opposite the petals, in contrast to the usual alternate arrangement. Important families, *Saxifragaceae* (chiefly confined to temperate zones. Includes the currant and gooseberry), *Crassulaceae* (fleshy herbs common in dry, sunny places. The house-leek and live-for-ever are examples), *Platanaceae* (members of the genus *Platanus* are often grown as shade trees. Includes the American plane-tree).

ORDER 19.—ROSIFLORAE. An important order, especially in the temperate zones, though represented by the single family *Rosaceae*. The regular and commonly conspicuous flowers nearly always have numerous stamens and separate carpels. The leaves are alternate and have stipules. The petals are often increased in number, as in the cultivated roses. Mostly woody plants. Includes very many common fruits, as the apple, pear, quince, strawberry, blackberry, cherry, plum, apricot, peach, etc. The few *Rosaceae* in the Philippine Islands are largely confined to the higher altitudes.

ORDER 20.—LEGUMINOSAE. The most important order of this division in the Philippine Islands and second only to the *Compositae* in world-wide display. The *Leguminosae* may be readily distinguished by their characteristic fruit. It results from a single carpel which has many ovules attached in two rows; a pea-pod is a familiar example. The leaves are nearly always compound and with stipules. The largest family in the order is the *Papilionaceae*. These have flowers of the sweet-pea type, *i.e.*, not radially symmetrical but with a "keel" and "wings." Of the two other families the *Mimosaceae* have regular flowers, while those of the *Caesalpiniaceae* are only slightly irregular. The order includes a host of Philippine forms which range in vegetative form from small herbs to some of the tallest trees. The *Mimosa* or sensitive plant is a very common herb. Species of *Pithecolobium* and *Acacia* are widely cultivated as shade and ornamental trees. Many of the most valuable of Philippine timber trees, narra, supa, acle, cupang, ipil and tindalo, are included in this order.

ORDER 21.—MYRTIFLORAE. The flowers are much like those of the *Rosiflorae*, but the carpels are always united and there are usually four petals and four sepals. Also, the leaves are opposite and without stipules. The best known Philippine member of this order is the guava or bayabas (*Psidium guava*) which belongs to the family *Myrtaceae*. To this family also belongs the genus *Eugenia*, represented in the Philippines by many large-tree species, some of which have considerable timber value. *Eucalyptus*, the genus to which belong the giant trees of Australia, also belongs to this family. The families *Lythraceae* and *Melastomataceae* are represented in the Philippines by numerous tree species.

HYSTEROPHYTA.—A provisional order including for the most part plants which have a parasitic habit and

are therefore regarded as being of recent origin. The mistletoe (*Viscum album*) is a familiar example of the family *Loranthaceae*. A species of *Rafflesiaceae*, a family of leafless parasites confined to the tropics, produces the largest known flowers, over a metre in diameter. This species occurs in Sumatra. The sandal-wood is produced by a tree parasite, a member of the *Santalaceae*. The wild ginger (*Asarum*) furnishes a familiar example in the United States of the family *Aristolochiaceae*.

B. SYMPETALAE.—Flowers with united petals; stamens usually inserted on the corolla.

ORDER 1.—ERICINAE. This order may be regarded as somewhat intermediate between the two great divisions of Dicotyledons. Not infrequently the petals are separate and the stamens inserted on the top of the floral stem. The stamens of the outer whorl are opposite the petals. The ovary has many seed-cavities. Leaves small and entire, usually leathery and evergreen. The stems are nearly always woody and short and branching close to the ground. The *Ericaceae* (heath-family) form a majority of the order. They are widely distributed over the whole earth, running well into high latitudes. The malaclac is a Philippine example. Members of the *Pyrolaceae* (winter-green, indian-pipe) are well known in the United States.

ORDER 2.—DIOSPYRINAE. This rather small order is of special importance on account of the high value of several forest products produced by its members. Gutta-percha and ebony both come from species of this order. The flowers resemble those of the preceding order, but the stamens are always attached to the corolla. Gutta is derived from species of *Palaquium*, a genus of the family *Sapotaceae*, which also includes chicko and betis.

The family *Ebenaceae* yields the well known woods camagon and bolong-eta as well as the true ebony. The *Styracaceae*, from which the resin benzoinum is derived, is also represented in the Philippines.

ORDER 3.—PRIMULINAE. An order exhibiting great diversity in vegetative structure. Not of importance in the Philippines. The stamens are adnate to the corolla, the gynoecium consists of five carpels, and the ovary has a single seed-cavity in which the seeds are attached to a central column. The *Primulaceae* (primrose-family) include many forms well known in temperate regions, as the cow-slip, cyclamen, loose-strife, pimpernel, etc. The *Myrsinaceae* are represented in the Philippines by species of *Ardisia* (quio), used as ornamental plants. The *Plumbaginaceae* are for the most part natives of the sea coasts and deserts.

ORDER 4.—CONTORTAE. An heterogeneous order whose members may be distinguished from other SYMPETALAE with radially symmetrical flowers by their opposite and entire leaves. The name of the order is derived from the fact that the corolla is usually contorted or twisted in the bud. The *Oleaceae*, the *Loganiaceae*, and the *Apocynaceae* are all represented in the Philippines, the latter by the valuable wood lanete, and the very common shrub pandacaqui. The lilac and the jessamine are familiar examples of the *Oleaceae* in the United States. The olive-tree (*Olea Europea*) also belongs here. The *Asclepiadaceae* are familiar as the milk-weeds. The *Gentianaceae* (gentian family) is included.

ORDER 5.—TUBIFLORAE. Despite great variation of vegetative aspect, the structure of the flowers shows a close affinity between the members of this order. The best known members of the order belong to the family

Convolulaceae, herbaceous climbers. The morning-glory (*Ipomea*) is an example. The family is well represented in the Philippines. The flowers of the order are regular, the stamens complete in number, always inserted on the corolla, and the ovary has two seed-cavities with two ovules in each cavity. The leaves are alternate. Here belongs also the family *Boraginaceae* (borage family), widely represented in the North Temperate zone by hairy weeds with succulent stems. It is also present in the Philippines.

ORDER 6.—PERSONATAE. Herbs and woody plants usually with large flowers. The potato-plant is a familiar example. The flowers are usually not quite radially symmetrical, having two lips. Commonly there are four stamens, arranged in pairs of unequal length. The ovary is composed of two carpels and has two seed-cavities with numerous seeds. The *Solanaceae* include the potato (*Solanum tuberosum*), the tomato (*Lycopersicum esculentum*) and, most important in the Philippines, the tobacco-plant (*Nicotiana tabacum*). The *Scrophulariaceae* show a strongly two-lipped corolla. They are usually root-parasites, though having green leaves. The mullein is a familiar example. Some species of this family are cultivated in Manila as ornamental plants. The *Bignoniaceae* are not uncommon in Philippine forests.

ORDER 7.—LABIATIFLORAE. Here the corolla is decidedly two-lipped. The order is made important by the large cosmopolitan family *Labiatae* (mint family). The flowers of the order have the number of stamens usually reduced, an ovary with two seed-cavities and four erect ovules, and each seed-cavity is subdivided by a false partition. Members of the mint family may be readily recognized by their square stems and opposite leaves in

two rows. They are all herbs or small shrubs. Their characteristic odor and general hairiness adds to the distinction. They are common in the Philippines. The *Verbenaceae* include certain very important members of the Philippine forest flora. Here is included molave, the finest of building timbers, delondon and agubarao. *Tectona grandis*, which yields the teak, belongs to this family.

ORDER 8.—RUBIINAE. Plants having little in common in the vegetative structure save the character of opposite leaves. They include herbs, shrubs and some trees. The flowers are usually small and aggregated in profuse clusters. In distinction to the preceding orders of the SYMPETALAE, the corolla always arises *above* the ovary. The calyx is greatly reduced and the ovary has two or three seed-cavities. The *Rubiaceae* form one of the largest and most varied families of plants. They are very common in the Philippines. *Gardenia* is a familiar genus. Here also is included *Coffea arabica* (the coffee-plant). The *Caprifoliaceae* are common shrubs, including the honey-suckle, the viburnum, and the elder. *Valerianaceae* (valerian family) is also included.

ORDER 9.—CAMPANULINAE. Mostly herbs with simple, entire, and alternate leaves. A milky juice is characteristic of most. The corolla arises above the ovary, the sepals are united, the stamens are inserted on the flower-axis, and the anthers are commonly adherent to each other. The flowers occur in somewhat elongated clusters. The *Campanulaceae* are very common in the North Temperate zone to which they are almost exclusively confined. The bell-flower is a familiar example. The *Cucurbitaceae* (melon family) are familiar throughout the world.

ORDER 10.—AGGREGATAE. This is the most successful order of plants, as well as distinctly the highest in

organization. Members of the *Compositae* (the composite family) are familiar everywhere, characterized as they are by the aggregation of numerous small flowers so that a single blossom is simulated. The dandelion and daisy are, perhaps, the most familiar examples. The flowers are very constant in character, always having the corolla superior to the ovary, the calyx rudimentary, the anthers usually adherent, and the ovary invariably with one seed-cavity which is quite filled by the single ovule. The corolla-like structure of the apparent blossom is formed by the asymmetrical extension of the corollas of the marginal or "ray" flowers. The *Compositae* are very common in the Philippine Islands, although their flowers are not so conspicuous as those of the familiar forms which are dominant in the summer and autumn flora of the United States.

APPENDIX.

The following blank forms are added as a definite guide to the making of notes and sketches. The notes should always accompany the sketches, and sketches should always be made, however crude. Their value consists not in their artistic quality, but in their accuracy. To make them carefully is an invaluable aid to accurate observation, for the most "seeing" eye easily fails to note, or notes without remembering, details which would certainly be brought out forcibly by reproduction in a sketch. The beginner will find it worth while to use the following pages in trying his 'prentice hand, using the blank pages for sketching and filling in the forms which face them with the corresponding notes. The sketches should include:

1. The general character of flower and foliage. This can usually be shown in a single sketch.

2. Floral details which may not be brought out in the general sketch, such as the number and the character of insertion of the stamens in flowers with united petals.

3. When the individual flowers are small, an enlargement of a single flower.

4. A cross section of the ovary.

5. The fruit.

6. Any striking details not included in the foregoing.

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Gynœcium .....

Anther .....

Pollen .....

Andrœcium .....

Ovary .....

Style .....

Stigma .....

Fruit .....

Seeds .....

Description of locality in which collected .....

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Date of collection .....

Common Name .....

SKETCHES.

PLANT DESCRIPTION.

General characters of the plant as a whole .....

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Flower .....

Calyx .....

Sepals .....

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Series 2477